# ACCIDENT PRODUCING CONDITIONS IN ORGANIZATIONS

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## ABSTRACT

This paper discusses aviation safety issues which diminish the effectiveness of current safety programs. The discussion begins with a brief review of the historical accident history for commercial jet aircraft from 1959-1996. The high percentage of human error accidents over this extended period illustrates the lack of safety improvements even though human error reduction programs, such as Crew Resource Management (CRM) been the focus of air carrier training for over one-half of this time period. This discussion postulates the problems with CRM implementation. Accident precursors within an organization are then discussed and a new paradigm for analyzing active failures in the cockpit, contextual triggers and latent managerial failures is introduced.

## BACKGROUND

Historically 73.3% of all commercial jet aircraft accidents worldwide were attributed to human error over a 38 year period from 1959 to 1996 (Boeing, 1996). However, the simple identification of this cause/factor does not contribute substantively to the important goal of improving aviation safety in the future. In fact, the use of “pilot error” as an accident cause/factor by governmental agencies, equipment manufacturers, and airline management is a subtle manifestation of the human tendency to narrow the responsibility for tragic failures that receive wide media coverage (Roscoe, 1980). These failures can be related to the human operator, the aircraft in use, and to the environment in which both the human and equipment must operate which constrains and shapes the resultant outcome. Pilot or crew errors are the symptoms of a mismatch between the goals, abilities, procedures and limitations of these different agents and system components, not simply an operator problem as suggested by the term “pilot error”.

### Problem Description

Studies of aircraft accidents undertaken as early as 1947 showed the weakness of training individual pilots to rely solely on their own judgment and experience to control an aircraft and then summarily dismiss any accident as a result of pilot error (Parke, 1995). Later studies conducted by industry, military, FAA and NTSB documented that about 75% of major accidents were ascribed to some type of pilot action or inaction. In 1978, a United Airlines DC-8 ran out of fuel and crashed during an approach 12 miles from Portland International Airport. The aircraft had delayed southeast of the airport for one hour while the flight crew analyzed a landing gear malfunction. The NTSB determined the probable cause of the accident was the failure of the captain to monitor properly the aircraft’s fuel state, and to properly accept and respond to inputs from junior crewmembers’ advisories regarding fuel state. Contributing to the accident was the failure of the crewmembers to fully comprehend the criticality of the fuel state or to assertively communicate their concerns to the captain (Driskel and Adams, 1992). This landmark accident lead to an NTSB recommendation that all captains and flight crew members receive some type of communication, assertiveness and decision making training. It resulted in the first generation of airline programs entitled “Cockpit Resource Management”.

These first generation programs were adapted from traditional *management development training*. They provided a heavy focus on psychological concepts, psychological testing and general leadership styles. They developed general strategies of interpersonal behavior without providing clear definitions of appropriate flight deck behavior. For example, United Airlines response to the NTSB recommendation was to develop their training program with the aid of consultants who had developed programs for corporations trying to enhance managerial effectiveness. Their program was modeled after a form of training called the “Managerial Grid” (Blake and Mouton, 1964). It consisted of intensive seminar type of training, which included participants’ diagnosing their own managerial styles. Other airline programs developed in the late 1970s and early 1980s also relied heavily on similar management training approaches.

Since about 1982, second, third and fourth generation CRM programs have been developed to include flight attendants, dispatchers, and maintenance personnel in comprehensive Crew Resource Management and Advanced Qualification Program training. Ironically, however, these skills and practices have been limited to operational flight personnel. They have not been applied “upstream” to include the *managers* of airline organizations even though the principles were derived from corporations trying to enhance managerial effectiveness. This deficiency, coupled with the major change in upper level managers underlies the current difficulties in developing and maintaining long-term safety programs. Upper level airline management used to be comprised of captains and engineers who had been promoted to the V.P. or Board of Directors levels. Today, these high echelons of management belong to M.B.A.’s and lawyers unfamiliar with operational demands and pressures. These changes are the major reasons for re-examining what basic organizational psychology principles could be used to mitigate the latent, error producing conditions which set-up flight crews for an active failure in the cockpit.

A comprehensive organizational resource management (ORM) program should be able to identify and address these error producing conditions. Basic principles such as active listening, conflict resolution, leadership, follower ship, interpersonal climate, communication, planning, workload distribution, etc. were, and still are, applied to the human interactions on the flight deck in an effort to reduce the large number of human error related accidents. However, it has now been realized that these same basic principles should extend beyond the cockpit and must be applied across airline or organizational management levels in order to attain stable, long term aviation safety programs that will reduce human errors. That is, *we have come full circle in realizing the interactions and influences of organizational policies, management styles, financial stability of the corporation, etc. on the day-to-day performance of flight crews during both normal and non-normal operations.* In fact, understanding and acting upon that understanding is the only way to mitigate the latent pathogens within an organization, reduce the negative influence of environmental factors on safety and maximize the performance of flight crews.

## A NEW PARADIGM

As a result of the long-term research and operational experience with Crew Resource Management (CRM) in aviation, we now know that pilot and crew errors, which can precipitate an accident, are often consequences arising from complex interactions between (Reason, 1999):

- Active Failures in the Cockpit
- Environmental and Operational “Triggers”
- Latent Failures originating in the Managerial and Organizational arena

Organizational Resource Management (ORM) to reduce human error accidents must consider the organizational, as well as, the operational factors that can set-the-stage for an accident. The last 20 years of human factors research has also shown that mental states occurring immediately prior to an error, for example, momentary inattention, forgetfulness, preoccupation, and distractions, are the last and the least manageable parts of an accident causal history. The actual causal history reaches back to the nature of the task, the local conditions within the workplace and the antecedent systemic factors that shaped those conditions.

In order to analyze and trace the organizational factors, which can lead to active failures, a more macroscopic perspective of the accident error chain must be considered. A systematic approach should be developed that expands the typical “error chain”. It needs to extend the accident cause/factor analysis from not only the flight personnel whose errors have directly played a part in the active failures, but to all of the individuals in the system that could have been responsibly involved. A major contribution to this effort has been the identification of the latent conditions in the organization that have laid dormant for some time until a combination of circumstances triggers the final human error. Passive latent errors are not only errors in themselves, but they also increase the potential for later active human errors in the organization.

Active failures, which are the type most often analyzed, have an immediate and direct impact upon the accident or incident. They receive immediate attention. If an organizational resource management approach is used to analyze normal operations and investigate accidents, latent conditions can be identified and mitigated. Table 1 illustrates the relationships between latent conditions and active failures (Maurino, et al, 1995).

Table 1 Organizational Resource Management

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|---|---|
| Local working conditions | Defenses, barriers and safeguards |
| Active failures | Latent conditions |
| Local triggers | Local triggers |
| **MISHAP** | |

Those in direct contact cause active failures with the system such as pilots, air traffic controllers, mechanics, dispatchers, etc. They are relatively easy to identify. For example, in the 73.3% human error, hull loss accidents identified by Boeing (1996), 50% of those were “triggered” by some type of procedural error. In contrast, latent conditions are usually a part of the organizational culture and more difficult to identify. Regardless, if the 38 years of 73.3% of the accidents being “blamed” on pilot error is to be influenced by improved safety programs, the organizations must deal with both active and latent failure conditions.

A review of air carrier accidents from 1978 to 1990 (NTSB, 1994) illustrates the diversity and interrelationships of latent organizational failures, environmental triggers and active failures. During this 13-year period, 302 specific human errors were documented in a total of 37 accidents (about 8 human errors per accident). Of the 302 specific human errors, 84% were in the Crew Resource Management arena of communications failures in the specific area of monitor/challenge interpersonal skills. However, 75% of these human errors were influenced by operational and organizational conditions where external factors combined with basic human deficiencies to result in an accident. In addition, 73% of these human errors involved fatigue which is the responsibility of the individual, but influenced by organizational decisions and operating procedures. Finally, over 50% of the accident flight crews were operating under time pressure involved with maintaining scheduled performance.

Management as a Cause Factor

It had been proposed as early as 1974 that management is at least partially implicated every time airline personnel are identified as the “primary cause” of an accident (Prendal, 1974). An example will be used to illustrate the interactions between management decisions/policies, latent conditions and active failures that led to an accident.

On Friday, March 10, 1989, two experienced crewmembers were teamed to fly an Air Ontario Fokker on two short trips from Winnipeg, Manitoba to Thunder Bay, Ontario and back with an intermediate stop at Dryden. This is basically a route that takes the aircraft from Winnipeg in an eastbound direction to Dryden and then in a southeasterly direction from Dryden to Thunder Bay. This day had been frustrating to the captain due to several operational factors: heavier than forecasted passenger loads, deteriorating weather, and less than optimum operational status of the aircraft. Combined, these factors produced numerous delays. Ultimately, these factors resulted in an inappropriate decision by the captain to takeoff with ¼ - ½ an inch of snow and ice on the wings noted by flight attendants and two deadheading captains, but not reported to the flight crew (Job, 1998).

Regardless, the fact remains that in the captain’s mind, under the existing conditions, based on his knowledge of the situation, and his perception of the pre-accident events, he was making the right decision to takeoff. Unfortunately, the Fokker became a mound of smoldering metal less than one kilometer from the departure end of the runway. Twenty-one passengers and three crewmembers, including the captain, perished.

Several obvious questions arise from this scenario. First, why did an experienced flight crew with thousands of flight hours experience in cold weather operations in scenarios similar to the day of the accident ignore all of the indicators presented to them? Second, why did two normal, healthy, competent and properly certificated individuals allow their behavior to cause the destruction of a well-equipped, state-of-the-art jet aircraft and the loss of their own lives. Finally, why have so many humans made similar inappropriate and damaging decisions over a 38-year period? The following description of pre-accident events will begin to answer these questions. The description was adapted from Job (1998) and shortened to enhance readability.

*Accident Events*. Although highly experienced (24,000 total flight hours), the captain had been in command of F28’s for only two months and had only 80 hours in type. However, he was highly regarded for his operating standards, sound decision making and safety consciousness. Furthermore, he was a stickler for punctuality, with a strong sense of responsibility for the welfare of his passengers. Air Ontario applied restrictions to takeoffs and landings by captains with less than 100 hours in command of the F28 aircraft and the forecast indicated that weather conditions could deteriorate below the captain’s landing limits. In this case, the only viable alternative was a town some 225 miles further east of Thunder Bay (Sault Ste Marie). This required excess fuel reserve in lieu of a full passenger load.

The next glitch in the operation was an Auxiliary Power Unit (APU) had been unserviceable for the preceding five days. This posed an additional problem since Dryden did not have ground equipment for starting an F28. For this reason, the company’s operations control headquarters authorized the crew to leave one engine running during the stops at Dryden. This further complicated operations, negatively impacted safety and added stress and frustration for the captain. This meant that the aircraft would have to perform "hot refueling" with passengers on board the aircraft. This procedure was not prohibited by the Air Ontario pilots operating handbook, but it was contrary to the company's flight attendants" manual. In addition to the defective APU, there were several other cabin anomalies:

1. a passenger door that was difficult to close
2. unserviceable emergency exit lighting
3. missing oxygen equipment.

The captain expressed his frustration that these had not been rectified (Job, 1998).

The flight left Winnipeg with only 11 on board out of 65 total seats. The flight landed at Dryden 13 minutes behind schedule. When the pilot telephoned Air Ontario operations, he was told that the weather minimums were below landing limits, but there were signs of improving. The flight took off about 20 minutes behind schedule with 30 passengers on-board.

For the flight back to Winnipeg, designated as flight 1363, the passenger loading was 55 from Thunder Bay to Dryden and 52 from Dryden to Winnipeg. Again, Sault Ste Marie was the alternate, and the aircraft was required to carry a total of 15,800 pounds of fuel. After refueling had been completed, and all the passengers were loaded, an additional 10 passengers from a cancelled Air Canada flight were added to the F28's load bringing it up to the maximum 65 passengers. The captain wanted to "bump" or off load 10 passengers, but the Air Ontario's Operations Control countermanded his decision, and instructed him to offload fuel. The defueling operation took an extra 35 minutes and some of the Winnipeg passengers with connecting flights were becoming anxious. The F28 finally departed for Dryden a full one hour late. Again, the captain, a professional known for his commitment to on-time performance and concern for his passengers experienced frustration, a sense of lack of control, and management induced time pressure.

Upon arrival at Dryden, the captain left the flight deck to telephone Operations to inform them that there would be a further delay while the aircraft took on more fuel. The telephone exchange became heated, the captain slammed down the handset, and two passengers reported the captain as appearing frustrated and disgusted (Job, 1998). Passengers reported that neither he nor the first officer conducted a 'walk-around' inspection of the aircraft.

Finally, the doors were closed and the aircraft started to taxi in a thin film of slush covering the taxiway. At this time, the aircraft's wings were covered with between ¼ to ½ an inch of snow changing to ice on the leading edge due to the cold soaking phenomenon. Cold soaking occurs when an object has been in a cold temperature long enough for its temperature to drop to or close to, the ambient temperature. Such is the case of the wing of an aircraft at high altitude and the fuel contained in its tanks. Upon landing, the skin of the aircraft will warm quickly, but not the fuel, which will warm much more slowly. The cold soaked fuel touching the wing surfaces will cause the moisture in the air to frost. As little as a tenth of an inch of frost can increase stalling speed by 35% (Dole, 1993). This roughly doubles the required takeoff distance. Rain or wet snow will then freeze to the upper surface of the wing resulting in an irregular, rough ice surface that further increases drag and reduces lift. In addition, the extra weight of the ice and snow adhering to the wing further increases required thrust for a safe takeoff. The captain asked maintenance whether or not deicing capabilities were available. The response was "yes", but neither the captain nor the ground personnel pursued the issue any further. This should have been the first sign to the other crew members that the captain's decision making had deteriorated significantly. Delaying the departure for deicing offered an opportunity to break the accident error chain, but it was not taken.

As the aircraft began to taxi, the first officer called flight service to request an IFR clearance to Winnipeg. But before this could be passed on, a Cessna 150 called flight service in urgent tones, reporting 4 nautical miles south of Dryden and inbound for landing. The Cessna declared he was having "real bad weather problems" and asked if there were "any chance that plane (the Fokker) can hold". The captain of the Fokker called the Dryden tower and advised they would hold. "I can't believe there's a small plane coming in," he declared with exasperation. "God knows how long we'll have to wait." He then repeated the information to his passengers on the PA system, preceding it with the words: "Well folks, it just isn't our day." (Job, 1998).

## RESULTS

An event is defined as the "breaching, absence or bypassing of some or all of the defenses and safeguards" (Maurino, et al, 1995). Organizational considerations vary from managerial decisions to conditions in the workplaces involved (e.g.. flight deck, hangar, control tower, etc.), and to personal and situational factors that lead to errors and violations. The event may result in either a catastrophe or simply result in an incident and on-the-job training depending on mere chance and the implementation of operational defenses. Organizational decisions, as well as the workplace environment influences all decisions made by the active participants.

Events leading to the Fokker accident were numerous, but can be examined in terms of: the local working conditions, active failures, latent conditions and local triggers previously presented in Table 1.

Local Working Conditions

1. Job instability following a merger
2. Different corporate cultures
3. High employee turnover
4. Low morale
5. Poor support to operational personnel

<u>Active Failures</u>

1. Crew did not de-ice
2. Crew did not walk-around
3. Cabin crew did not communicate
4. Ground handler reticince
5. Dispatch did not update weather flight release deficiencies

<u>Latenet Conditions</u>

1. No safety organization
2. No safety officer
3. Ambiguous Minimum Equipment List
4. Ambiguous operative, dispatch and maintenance procedures
5. Lack of standardized manuals
6. Training deficiencies
7. Crew pairing
8. Poorly managed corporate merger
9. Deficiencies in Standard Operating Procedures
10. Regulatory deficiencies
11. No licensing required for dispatcher
12. No training regulating for dispatchers
13. Deficient F28 audit

Local Triggers

1. Weather conditions
2. APU inoperative
3. No ground start equipment
4. Cessna 150 wandering around
5. Crew frustrations
6. Delays/passenger connections

## CONCLUSIONS

Organizational decisions and policies in the high levels of the system can seed organizational pathogens into the operational system that lead to human errors at the local event level. These pathogens take many forms: managerial oversights, ill-defined policies, lack of awareness of risks, inadequate budgets, lack of legal control, deficient maintenance management, excessive cost cutting, poor training, poor personnel selection, ill-defined responsibilities, commercial pressures, and unsuitable equipment. The adverse consequences of these pathogens are transported to the workplace environment to create latent failure conditions and promote local active failures.

At some point, these latent conditions and active failures may act to create an undesirable event (incident or accident). These events may arise through the complex interaction between the active and latent conditions and local triggers. Both the local triggering factors and random variations can assist in creating an incident/accident opportunity.

The remedial implications of the theoretical framework developed by Maurino, et al (1995) is both proactive and reactive. By specifying the organizational and situational factors involved in the causal pathways, it is possible to identify potentially dangerous latent failures before they combine to cause an accident. The same framework can also be used to track from an accident or incident to the active latent failure and its organizational roots.

The message from this taxonomy is clear. First, the pilot-in-command must bear the responsibility for the decision to land and takeoff at Dryden. However, it is equally clear that the air transportation system failed by allowing him to be placed in a situation where he did not have all of the necessary tools and support mechanisms to make the proper decision. Second, there is no substitute for properly trained, professional flight crews and operational personnel. But, no matter how high their degree of professionalism, humans can never outperform the system which bounds and constrains them.

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